IMPLEMENTATION OF INFORMATION COMMUNICATION TECHNOLOGY BASED LIBRARY STANDARDS IN COLLEGE LIBRARIES OF COASTAL KARNATAKA

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1. Introduction

The integration of Information Communication Technology (ICT) has revolutionized contemporary library systems, reshaping traditional practices of information access and management (Ekwelem, 2019). Moving beyond physical collections and manual catalogues, libraries now function within hybrid or digital ecosystems, offering seamless access to e-resources, databases, repositories, and multimedia content. In this digital transformation, ICT-based library standards play a crucial role in ensuring consistency, interoperability, and service excellence.

Library standards comprise structured guidelines and best practices that govern every operational facet—cataloguing, classification, digital access, and user interface design. These standards not only support technical operations but also promote ethical values such as intellectual freedom, privacy, and equitable access to information. As libraries evolve into knowledge hubs, the adherence to global standards guarantees service quality and system reliability, facilitating user-centered innovations.

Particularly in academic institutions, adherence to ICT standards is vital for aligning with international benchmarks. In college libraries along the coastal belt of Karnataka, this transition is especially critical. The integration of ICT-based standards can significantly enhance library functionality, ensuring relevance in an increasingly digital academic landscape. These standards guide the digitization of collections, manage electronic resources efficiently, and foster intuitive user experiences (Meghanandha & Naik, 2023). The present study explores the status, of implementing ICT standards in college libraries across Coastal Karnataka. It aims to assess the current adoption level, identify barriers, and propose strategic models for sustainable integration. By focusing on this unique regional context, the study underscores the transformative potential of ICT standards in enriching academic library services and fostering institutional excellence.

1.2 ICT based library standards

ICT-based library standards have revolutionized information management, enabling interoperability, efficiency, and consistency across operations. These standards structure the organization of digital resources, support automation, and facilitate networking protocols for seamless information exchange (Joudrey & Taylor,

2017). Tools like MARC and BIBFRAME ensure metadata uniformity, while OAI-PMH and Z39.50 enhance resource sharing (Breeding, 2019). Robust ICT infrastructure—cloud systems, secure repositories, and AI tools—enhances service delivery and user engagement through personalized recommendations (Meesad & Mingkhwan, 2024). Trained human resources are vital for implementing these technologies, necessitating regular upskilling and user education (Yadav et al., 2024). However, libraries face barriers including budget limitations and technological disparities. Overcoming these requires strategic investments and policy reforms. Innovations like blockchain, IoT, and AI-driven automation signal the evolving future of library standards (Ulrich et al., 2022), positioning libraries as sustainable, tech-driven knowledge hubs.

1.2.1 Library Automation, Networking, and Software Systems

Library automation, networking, and software systems have revolutionized traditional operations by enhancing efficiency and expanding access. Automation streamlines cataloging, circulation, acquisition, and serials control, reducing manual tasks and improving accuracy. Metadata standards such as MARC, Dublin Core, and BIBFRAME ensure interoperability and consistent data management (Elizarov & Lipachev, 2020). Library networking fosters resource sharing and collaboration through protocols like Z39.50 and OAI-PMH. Initiatives such as OCLC and INDEST strengthen cooperative cataloguing and interlibrary loan services, widening digital access (Kumar & Verma, 2022). Software systems—both open-source (e.g., Koha, Evergreen) and commercial (e.g., Ex Libris Alma, SirsiDynix Symphony)—offer integrated, cloud-based solutions. Features like AI-powered search and big data analytics enhance scalability and user experience (Huang et al., 2023). Integrating automation, robust networking, and advanced software is essential for developing responsive, efficient, and future-ready library services.

1.2.2 ICT Standards in Library Operations

ICT standards are fundamental for ensuring consistency, interoperability, and operational efficiency in libraries. These standards provide structured frameworks for managing digital assets, integrating automation systems, and facilitating seamless information access. Their adoption enhances service delivery, streamlines metadata

workflows, and ensures broader access to digital collections. Central to these standards is metadata management, which guarantees uniform cataloging and effective resource discovery. Protocols such as Machine-Readable Cataloging (MARC), the Dublin Core Metadata Initiative (DCMI), Metadata Object Description Schema (MODS), and BIBFRAME support bibliographic data exchange across diverse library systems (Foulonneau & Riley, 2014). Digital preservation standards are equally vital, safeguarding the longevity and integrity of electronic resources. Frameworks like the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH), Preservation Metadata Implementation Strategies (PREMIS), and the Trusted Digital Repository (TDR) model guide secure storage and access (Corrado & Sandy, 2017). Standards supporting information retrieval and resource sharing, including Z39.50, Resource Description and Access (RDA), and linked data principles, facilitate global bibliographic integration (Cen, 2024). Implementation of these standards demands modern infrastructure and innovative technologies such as AI for metadata automation, blockchain for digital rights management, and scalable cloud platforms to enhance efficiency and accessibility (Wells, 2022).

1.2.3 ICT Infrastructure and Facilities

ICT infrastructure and facilities form the technological backbone of modern libraries, enabling integration of digital resources, automation, and user-focused services. A robust infrastructure improves library functionality, streamlines digital resource management, and promotes equitable access. Standardized facilities support advanced services like cloud storage, remote access, and automated circulation, fostering continuous learning. Networking and high-speed internet connectivity, including broadband, secure Wi-Fi, and Virtual Private Networks (VPNs), enable uninterrupted access to resources. SaaS-based Integrated Library Systems (ILS) enhance scalability and security of digital repositories (Smith, 2022). Hardware and software—such as digital workstations, e-book readers, self-checkout systems, and repository platforms—optimize daily operations. Library management software like Koha, Ex Libris Alma, and Sierra supports core functions including acquisitions and cataloging. AI tools facilitate intelligent search, metadata indexing, and automated classification. Strong data protection measures, including encryption, user authentication, and firewalls, are essential. Compliance with global standards like ISO/IEC 27001 and GDPR ensures data integrity. Blockchain secures digital

authenticity (Wang & Liu, 2023). Accessibility tools—screen readers, text-to-speech software, braille displays—must be prioritized for inclusive service delivery (Enríquez et al., 2022). Future-oriented technologies like 5G, IoT-based smart systems, and AR will accelerate the digital transformation of libraries (Johnson, 2023).

1.2.4 Library Personnel Management

Library professionals are key enablers of ICT-driven services. Their expertise in managing digital systems and emerging technologies is critical to service quality and innovation. Effective personnel management includes structured recruitment, continuous training, and motivation strategies to build a skilled and adaptable workforce. Regular digital literacy programs and professional development initiatives ensure librarians remain technologically competent. Incorporating AI in HR analytics supports personalized training, performance assessment, and career development (Garcia-Marco, 2023). Cultivating a culture of adaptability and innovation enables staff to embrace change and drive digital initiatives. Strong leadership, collaborative team dynamics, and internal knowledge-sharing platforms further strengthen personnel capabilities. By addressing digital skill gaps and overcoming resistance to change, libraries can establish a forward-thinking workforce aligned with technological progress. Such strategic human resource development ensures sustainable growth and high-quality, ICT-enabled library services (Kumar, 2023).

2. Literature Review

The literature review critically examines existing research, highlighting gaps and guiding scholarly inquiry. It draws from peer-reviewed journals, conference proceedings, and databases like LISTA, Open J Gate, JCCC@INFONET, Emerald, Elsevier, and DOAJ. Additional sources include digital libraries such as ACM, LDL, and thesis repositories like Shodhganga, E-ShodhSindhu, and NDLTD for comprehensive analysis and validation.

2.1 Thematic categorisation of related studies

A thematic literature review is a method of reviewing literature by organizing and discussing sources around themes or topics, which helps to highlight patterns, trends, and gaps in the research across multiple studies and offers a more synthesized

understanding of a subject. In the present chapter, the synthesis of studies is meticulously organized around the following key themes, ensuring a systematic exploration of research in the designated domains:

- ICT Infrastructure and Facilities;
- ICT-Enabled Library Platform;
- Library Automation and Networking System; and
- ICT-Based Library Standards

2.1.1 ICT Infrastructure and facilities

Information Communication Technology (ICT) has transformed libraries from traditional book repositories into dynamic digital information centers. The investigation of the implementation of ICT in 22 college libraries located in Nadia, West Bengal, revealed that these libraries are key access points for academic users and that automation plays a vital role in improving service efficiency. However, they found significant shortcomings in ICT infrastructure, including insufficient hardware, outdated software, limited internet access, and financial constraints that hamper progress (Sanjay & Singh, 2024).

John and Balasubramanian (2019), Amirthalingam and Subramanian (2015), and Selvakumar and Thandavamoorthy (2013) highlight the transformative role of ICT in academic and research libraries, improving efficiency, accessibility, and research capabilities. ICT-based resources are widely used, enhancing user satisfaction and service quality. R&D libraries leverage ICT for better information retrieval, benefiting the research community. However, challenges like inadequate infrastructure and financial constraints persist. Modern technologies can further optimize library management and research facilitation. Strategic planning, enhanced funding, and continuous staff training are essential for maximizing ICT benefits in libraries. The study emphasizes that ICT is indispensable for modern libraries, revolutionizing their role in knowledge dissemination and research support.

2.1.2 ICT-enabled library platform

The integrated approach enables ICT in libraries to manage infrastructure efficiently, offer personalized services, and maintain high-quality standards, fostering

ongoing improvement and user satisfaction. User evaluations of digital libraries are influenced by usability, collection quality, service standards, and system efficiency, all of which significantly affect user satisfaction (Heradio et al., 2012).

Gabbay (2024) and Quan Liu (2004) examine the web's transformative influence, offering insights into digitization methods, innovation strategies, and evolving technologies that shape modern digital libraries. The success of digital libraries relies on the effective integration of advanced technologies, standards, and protocols that govern content structuring, data transmission, authentication, and information display. Essential frameworks include Content Standards (PDF, JPEG, TIFF), Metadata Standards (Dublin Core, MARC, MODS), and Quality Standards (ISO 9001, ISO 16363). This explores digitization practices in US libraries, focusing on material selection challenges, standard implementation, and technological advancements. As libraries evolve into digital ecosystems, understanding emerging trends, best practices, and policy developments becomes crucial.

2.1.3 Library automation and networking system

The development of automated library systems in Lao PDR emphasizes interoperability, using a spiral model to design and test a prototype compatible with the Lao language and librarian needs (Ahammad et al., 2024). Sustainability in open-source library automation is closely tied to factors such as community support, adoption rates, technical expertise, and funding, requiring strong governance and training investments (Saythongdeth et al., 2021).

Priya and Ramya (2024), Senthilkumar et al. (2024), and Vijesh (2024) explore AI's transformative role in libraries, revolutionizing cataloging, indexing, and metadata creation while enhancing user experiences and optimizing workflows. AI-driven automation streamlines tasks, improves search precision, and advances digital preservation. Virtual assistants and chatbots provide real-time support, while learning analytics and behavior-based recommendations personalize content delivery. AI strengthens cyber security, facilitates trend forecasting, and demands continuous LIS professional development. Emerging technologies like neuromorphic computing and federated learning will further enhance operational excellence, ensuring libraries remain dynamic, inclusive, and essential knowledge hubs in the digital era.

2.1.4 Information communication-based library standards

Digital Rights Management (DRM) plays a crucial role in ensuring fairness, transparency, and security in the distribution of digital content by addressing issues of property rights, licensing, privacy, and confidentiality (Iannella, 2008). Metadata enables secure access across platforms, bolstering rights enforcement within DRM systems (Cote & Park, 2007).

Srikantha (2024) and Longo (2022) highlight that openURL is a standardized protocol for transmitting bibliographic metadata, enhancing resource discovery and interoperability in libraries. It integrates OPAC systems, electronic periodicals, and diverse digital resources, improving e-resource management. Compared to traditional linking methods, OpenURL offers more seamless access to referenced materials. Additionally, Distributed Simulation (DS) supports Digital Twins (DTs) by leveraging IEEE 1516 High-Level Architecture (HLA) for real-time simulation.

2.2 Inference

The literature underscores ICT's transformative role in Library and Information Science, shaping services through automation, metadata management, and structured models like ITIL and QoS. Prior studies highlight digital libraries' evolution, stressing the need for robust infrastructure and strategic planning. Adoption of global standards such as MARC, Z39.50, and OAI-PMH ensures interoperability and efficiency. However, challenges like inadequate funding, technical complexity, and skill shortages persist. Addressing these requires sustained investment and training. ICT-based standards by ISO, IFLA, and ACRL are vital for uniform service delivery. Continued empirical, interdisciplinary research is essential for refining standards and ensuring libraries' future adaptability.

3. Need and significance of the study

The rapid advancement of ICT has profoundly transformed the functioning of academic libraries worldwide. In this context, the integration of ICT-based library standards is essential to ensure efficiency, consistency, and alignment with global best practices. Coastal Karnataka, known for its academic diversity and concentration of higher education institutions, presents a contrasting reality that many college libraries

in the region continue to operate using traditional cataloguing systems or employ ICT tools in an ad hoc manner, without adherence to standardized frameworks. This inconsistency has resulted in issues related to interoperability, digital resource sharing, and the overall quality of library services.

Although certain institutions have adopted ICT infrastructure, the lack of uniform standards and structured implementation significantly limits the potential benefits of technology in libraries. Furthermore, disparities in professional training and awareness among library staff exacerbate the uneven quality of ICT integration. Therefore, this study is imperative to evaluate the current status of ICT-based library standard implementation, highlight disparities, document best practices, and identify the challenges faced by college libraries across Coastal Karnataka.

The significance of this study lies in its potential to transform the regional academic library landscape. By conducting a systematic assessment of ICT adoption, the research would provide critical insights to educational administrators, and library professionals, thereby facilitating the development of strategic frameworks for the effective implementation of ICT-based standards. Such standardization enhance system interoperability, enable seamless digital resource sharing, and improve the efficiency and accessibility of library services. This study supports national initiatives such as the study aligns with national initiatives such as the National Education Policy (NEP) 2020 and the Digital India Mission, both of which underscore the significance of digital transformation in education. The present study inform the development of capacity-building programs for library professionals, support institutional planning and resource allocation, and serve as a reference for formulating region-specific ICT policies. Ultimately, this research seeks to contribute to the establishment of a modern, inclusive, and technologically empowered academic library system in Coastal Karnataka.

4. Statement of the problem

The present study aims to assess the implementation status of different library standards in degree college libraries of Coastal Karnataka. Hence, the theme of the study is conceived with an expressive entitle: "**IMPLEMENTATION OF INFORMATION COMMUNICATION TECHNOLOGY BASED LIBRARY STANDARDS IN COLLEGE LIBRARIES OF COASTAL KARNATAKA"**

4.1 Meaning and definition of the concept

A concept is a well-defined idea that helps in understanding a specific subject. Definitions explain their meaning, features, and use in a structured way. The meaning and definitions of key concepts are given below:

i. Information communication technology

UNESCO (2025) defines ICT is a "Diverse set of technological tools and resources used to transmit, store, create, share or exchange information. These technological tools and resources include computers, the Internet (websites, blogs and emails), live broadcasting technologies (radio, television and webcasting), recorded broadcasting technologies (podcasting, audio and video players and storage devices) and telephony (fixed or mobile, satellite, video-conferencing, etc.)"

ii. Library standards

ACRL (2018) defines **library standards** to "systematically developed guidelines and criteria designed to ensure consistency, quality, and efficiency in library services, operations, and resources. These standards encompass various aspects of library management, including cataloging, classification, staffing, collection development, facilities, and technological integration. They serve as benchmarks for evaluating library performance and are instrumental in facilitating interoperability, resource sharing, and the adoption of best practices across libraries"

In the present study library standards encompass critical areas such as Information Processing Retrieval standards, library automation standards, digital library standards, Metadata standards, Web Technology standards, and ICT infrastructure, and technological adoption. They serve as vital instruments for assessing library performance, promoting seamless interoperability, enabling effective resource sharing, and encouraging the implementation of best practices across libraries to create a robust and modern library ecosystem.

iii. Implementation

Cambridge Dictionary (2025) defines implementation as "the act of putting a plan into action or of starting to use something."

In the context of this study, implementation refers to the systematic process of putting library standards into practice within college libraries. It involves planning, adapting, and integrating standardized procedures, ICT tools, and policies to ensure effective functioning, improved service delivery, and alignment with national or institutional goals.

iv. College Libraries

IGI Global (2025) defines college libraries as "specialized academic libraries affiliated with higher education institutions, such as colleges and universities. Their primary purpose is to support the institution's curriculum and research activities by providing access to a wide range of resources, including books, journals, digital materials, and other learning tools. These libraries serve students, faculty, and staff, facilitating academic success through information literacy programs, research assistance, and access to both physical and electronic collections. College libraries are integral to the educational mission, fostering an environment conducive to learning, teaching, and scholarly inquiry"

The study views coastal Karnataka college libraries as essential components in fostering academic excellence, promoting digital literacy, and implementing standardized ICT practices to improve service delivery and resource management.

v. Coastal Karnataka

"Coastal Karnataka comprises Dakshina Kannada, Udupi, and Uttara Kannada districts along a 320 km coastline. It features diverse landscapes and supports numerous educational institutions. Libraries in this region function as key academic resources, facilitating education and research across urban and rural areas with varied population densities and geographic settings" (Karnataka Tourism, 2020).

The study presents Coastal Karnataka as an educationally vibrant region spanning Dakshina Kannada, Udupi, and Uttara Kannada. With diverse geography and population patterns, the region's college libraries play a central role in supporting curriculum-based learning, research development, and the implementation of ICT-based library standards.

vi. Integration

Cambridge Dictionary (2025) defines integration as “to combine two or more things in order to become more effective”.

In the context of this study, integration aims to enhance library functions such as cataloguing, resource sharing, user access, and service delivery, thereby improving overall efficiency and user satisfaction while aligning with established library standards.

5. Objectives of the study

The objectives of the research are as follows:

- To evaluate the awareness and utilization of ICT tools, facilities, networking, and software systems by library professionals in enhancing library operations;
- To analyze the level of awareness and usage of library standards among library professionals;
- To assess the implementation of ICT-based library standards in college libraries;
- To examine the status of training and development in ICT-based library standards for library professionals;
- To trace the challenges in implementing ICT-based library standards in the college libraries of Coastal Karnataka and to explore effective strategies for overcoming these challenges; and
- To suggest strategies for improving the awareness and implementation of ICT standards across college libraries in Coastal Karnataka.

6. Hypotheses

- There is a significant implementation of ICT-based library standards in college libraries of coastal Karnataka;
- There is no significant difference in the implementation of ICT-based library standards between government and private college libraries of coastal Karnataka;
- The implementation of ICT-based standards in college libraries of Coastal Karnataka has significantly improved operational efficiency;

– There is no significant integration of technological features into library automation software in college libraries of coastal Karnataka;

7. Methodology

Research methodology provides a systematic framework for research, ensuring reliability and validity. It is the blueprint of the research study, explaining how the research will be carried out in a structured, logical, and scientific manner. The present study adopts a descriptive design, using structured questionnaires, direct observations, and secondary data analysis to assess ICT-based library standards in Coastal Karnataka, enhancing credibility and meaningful insights.

7.1. Research design

The study adopts a descriptive survey research design to analyze the perceptions and utilization of various library standards by library professionals at different levels. The primary objective is to assess their awareness of, and integration with, ICT-based library standards within daily library operations. The research targets library professionals across diverse designations to evaluate their engagement with these standards, aiming to provide comprehensive insights into current practices, challenges, and the overall implementation of ICT standards in academic library environments.

7.2 Geographical area coverage

The study comprises Coastal Karnataka, covering Dakshina Kannada, Udupi, and Uttara Kannada districts. It explores the diverse landscape of analyzing variations in library standards implementation. The study assesses how these factors influence the adoption and usage of ICT-based library standards across different college environments.

i. Professional hierarchy

The study includes library professionals at all levels of the organizational structure within the libraries. These levels include:

– Chief Librarians - Selection grade librarian
– Deputy Librarians - Assistant Librarians
– Selection Grade Librarians - Guest Librarians
– Library Assistants

7.3 Population of the study

The study focuses on 155 colleges with 216 library professionals in Coastal Karnataka, identified through websites **(**Department of Collegiate, 2023) telephone calls, and personal visits. A total of 147 colleges with 206 professionals responded, providing diverse insights into the implementation of ICT-based library standards.

Table 1.1 Population and Response Received

Population of the study	Colleges	Library professionals
Total population	155	216
Questionnaire distributed	155	216
Response received in number	147	206
Response received in percentage	94.83%	95.37%

7.4 Pilot study

A study on ICT-based library standards was conducted in first-grade colleges, postgraduate centers, and education colleges affiliated with Kuvempu University. Engaging 96 LIS professionals and achieving a 96% response rate, the study validated the questionnaire and identified key strengths, challenges, and areas for ICT improvement.

7.5 Data collection tools

Data collection tools help gather accurate information needed to understand study. They ensure that the data collected is reliable and relevant for analysis.

i. Questionnaire

A comprehensive and well-structured questionnaire was designed to evaluate the awareness and utilization of ICT-based library standards among library professionals. It incorporates both quantitative (closed-ended) and qualitative (open-ended) questions. The questionnaire focuses on essential aspects such as familiarity with ICT standards, current usage practices, barriers faced in implementation, and the availability of relevant training resources, aiming to gather in-depth insights into the practical adoption of these standards.

ii. On premises review

Personal visits were undertaken to directly evaluate the implementation of ICT-based library standards within academic institutions. These assessments involved a thorough examination of ICT infrastructure, library automation systems, software applications, networking facilities, and the engagement of staff with digital tools. Key operational aspects, including system functionality, user interaction, and adherence to standardized practices, were carefully reviewed on-site.

During the visits, relevant queries were addressed, and doubts were clarified through direct interaction with library professionals. This method ensured the collection of accurate, reliable, and context-rich data, offering comprehensive insights into the practical adoption and challenges of ICT-based library standards.

7.6 Data analysis

Data analysis is the process of examining data to find useful information and understand patterns.

i. Data cleaning and preparation

Following data collection, the initial step involved thoroughly inspecting all responses for completeness and accuracy. Any missing or inconsistent data was carefully addressed.

ii. Comprehensive analysis and interpretation

After cleaning the data, it was coded and analyzed using MS Excel. These primary data were presented in the form of tables and figures, analyzing factors influencing ICT-based library standards adoption, highlighting strengths, challenges, and opportunities. Statistical tests were performed using SPSS (Statistical Package for the Social Sciences). The chi-square test was used to study associations between the different variables.

iii. Citation style used

Citations are provided wherever necessary and are supported by corresponding references. The investigator used the 7th edition of APA (American Psychological Association) style for citing and referencing.

8. Scope and limitations of the study

The present study focuses on the coastal Karnataka region, covering Dakshina Kannada, Udupi, and Uttara Kannada and examines ICT-based library standards in graduate and postgraduate college libraries. It includes Government, Aided, Autonomous, Constituent, and Private Institutions. The research evaluates ICT implementation, covering MARC21, Dublin Core, and ISO protocols for cataloging, metadata creation, and digital resource management. Library professionals at various hierarchical levels, from Chief Librarians to Library Assistants, are analyzed based on their roles in ICT adoption. The study highlights the varying degrees of engagement, expertise, and responsibilities in implementing technological advancements within college libraries in the region.

9. Organisation of the thesis

Chapter I: Introduction

This chapter introduces ICT-based standards and study objectives, defines key concepts, presents the research problem, and details the need, methodology, hypotheses, scope, limitations, and thesis organisation.

Chapter II: Review of literature

This chapter reviews literature relevant to the research problem, categorized into four areas: Digital Libraries, ICT Integration Systems, Library Automation and Networking, and ICT-Based Library Standards.

Chapter III: Part A - ICT based library standards
Part B – College libraries of Coastal Karnataka

This chapter outlines ICT-based library standards, their foundations, evolution, role in transforming library services, and examines higher education history and affiliated colleges in Coastal Karnataka.

Chapter IV: Data Analysis and Interpretation

This chapter contains detailed analysis and interpretations of the collected data. The data is presented in tables and figures.

Chapter V: Major Findings, Recommendations, and Conclusion

The present chapter provides major findings, recommendations, future research directions and finally the conclusion.

10. Major findings of the study

Libraries should upgrade ICT infrastructure, standardize automation software, and ensure regular updates for efficiency. Strengthening networking will enhance resource sharing. Adopting established ICT standards will improve service quality, interoperability, and long-term sustainability.

- Among 147 college libraries of coastal Karnataka 76.19% affiliated with Mangalore University and 23.81% with Karnatak University Dharwad followed by 50.34% established pre-1990.
- In terms of geographical distribution, 64.63% of the institutions are situated in urban regions whereas rural and semi-urban have least presence.
- High portion (85.03%) of institutions have NAAC accreditation out of which 50.4% of institutions are graded between A++ to A, indicating high quality.
- ICT has been implemented in 97.28% of libraries, reflecting strong institutional commitment to digital transformation.
- The majority of respondents (97.58%) reported being aware of ICT. Among them, females constituted 53.41%, librarians accounted for 49.52%, and those with less than five years of experience exhibited the highest level of awareness
- A predominant share of respondents (97.28%) reported the availability of ICT facilities. Notably, the highest availability was observed in colleges affiliated with Mangalore University (73.47%), institutions located in urban areas (63.95%), and NAAC-accredited institutions, where full access was reported.
- Private colleges reported the highest ICT availability (61.90%), followed by aided institutions (18.37%) and government colleges (12.93%).
- A total of 87.57% of users reported often or always using ICT, indicating high levels of engagement and consistent utilization of digital resources.
- The majority of respondents (91.55%) expressed ICT support in library operations. A total of 59.87% of respondents reported partial integration of ICT, whereas only 37.41% indicated full integration in daily operations

- Private colleges demonstrate 56.46% high to very high ICT integration, while other colleges show significantly lower levels.
- The major portion (97.28%) of respondents affirm ICT infrastructure efficiency in libraries, while 2.72% indicate minor inadequacy concerns.
- While 55.34% perceived the ICT infrastructure as adequate, while over 85% acknowledged effective maintenance and support for digital resources.
- The (48-59%) express high satisfaction with ICT integration aspects, reflecting effective library digital services.
- The 87.75% of institutions report technological advancement; private colleges lead (57.14%), government lag behind (8.84%).
- Most colleges (67.42%) update ICT infrastructure biannually or every few years and also rare updates persist.
- Major challenges include budget constraints (83.33%) and technical expertise shortages (77.77%) hindering ICT implementation.
- A majority of respondents (92.51%) reported successful implementation of library automation. While 64.45% of colleges have achieved partial automation, full automation is most prevalent in private colleges (20.58%
- EasyLib is the most widely used library automation software (40.44%), followed by Koha (24.48%), while other systems have minimal adoption. Private colleges (63.94%) lead in library automation software implementation, particularly adopting EasyLib and Koha systems.
- Most libraries lack modern ICT features; recommend the adoption of RFID, cloud, apps, websites, and kiosks.
- Circulation (70.39%), Acquisition (67.96%), and Cataloguing (66.99%) modules are mostly implemented across institutions.
- The highest portion of respondents (67.35%) reported no implementation of digital library software.
- A majority of respondents (61.90%) rated digital resource availability as 'Good', with private institutions leading at 40.82%. Other types of colleges reported comparatively lower ratings. 53.74% of colleges have implemented content management software, indicating a slight majority adoption.
- Drupal (81.55%) and Joomla (79.61%) show high moderate awareness.
- Private colleges lead in adoption of automation (59.18%), CMS (34.69%), and digital libraries (18.36%) software.

- EndNote (13.11%) leads in extreme familiarity, followed by Mendeley (11.65%). Respondents show OpenRefine (85.92%) and MarcEdit (83.49%) received the highest responses. Lucene (83.50%), Solr (83.49%), and Elasticsearch (80.09%) shows good awareness level
- The 91.83% have implemented ICT-based library standards, indicating widespread adherence across institutions. Private institutions (76.99%) show higher implementation of library standards compared to government institutions (13.29%).
- The highest portion ICT implementations (70.06%) occurred within the last 1–5 years, indicating recent digital transitions. 70.87% demonstrated awareness of ISO 27001 whereas awareness of ISO 8583 remains lower at 59.70%.
- Respondents show moderate awareness of IPR tools like CQL (86.40%), SKOS (85.92%), RDF (83.03%).
- MARC21 had highest extreme awareness (23.78%), while BIBFRAME (81.55%) and FRAD (80.09%) showed moderate awareness.
- Respondents exhibit moderate awareness of metadata standards, METS (87.86%) and DCMES (81.55%) rank highest.
- DHTML (88.34%) and XML (86.89%) show highest moderate awareness.
- IP (82.03%) and FTP/SFTP (81.06%) showed high moderate awareness.
- The majority of the respondents (92.52%) show interest in implementing emerging technologies; only 0.68% uninterested.
- The (59.55%) reported well adherence, while 33.08% showed very well adherence to ICT-based standards.
- Inadequate infrastructure (90.90%) and lack of skilled personnel (81.81%) are the leading adherence barriers.
- Despite overall 90.47% support, only 59.86% of private institutions confirmed adequate ICT-based standards support.
- A majority (92.52%) follow formal ICT standard processes, while 39.70% update them only every few years.
- The 50.97% found protocols somewhat clear; 4.38% found them unclear and difficult to implement.
- The 45.9% reported significant efficiency improvement after implementing ICT standards, indicating positive operational impact.

- Search and retrieval (64.07%) and cataloguing (50%) showed highest improvement through ICT-based implementations.
- Outsourcing technical expertise (77.55%) emerged as the major challenge during ICT implementation.
- Private institutions reported 71% staff training needs and 68.42% challenges in outsourcing technical expertise.
- Over 50% confirmed ICT standards improved efficiency, user satisfaction, access, and compliance in library services.
- Majority of respondents (88.34%) feel prepared or very well-prepared for future ICT trends, indicating strong readiness.
- Most respondents (85.44%) report moderate to significant progress in ICT implementation; few report no progress.
- Majority (81.99%) perceive the ICT support team as responsive, with minimal reports of unresponsiveness.
- Majority (80.10%) of respondents express optimism about promising future ICT development in libraries.
- Most respondents (96.08%) report high to very high interoperability with external systems, indicating strong integration.
- Predominance respondents (84.93%) report positive or somewhat positive impacts of ICT standards on overall efficiency.
- Greater portion of respondents (89.31%) recognize the importance of aligning ICT services with international library standards.
- The (69.90%) implemented formal staff training with ICT, effective for (50.69%)
- The 44.17% strongly agree on sufficient ICT training opportunities, 52.91% support certifications.
- The strong satisfaction with system integration (62.14%) and training relevance (58.74%), moderate digital access (56.06%)

11. Hypothesis testing

Hypothesis 1: *There is no significant integration of technological features into library automation software in college libraries of coastal Karnataka.*

The null hypothesis stated that there is no significant integration of technological features with library automation software in college libraries of Coastal Karnataka. However, chi-square test results were statistically significant across multiple dimensions ($\chi^2(1) = 70.618–116.735$, $p < .001$)). Thus, the null hypothesis was rejected, indicating that a significant level of technological integration exists in these libraries.

Hypothesis 2: *There is a significant implementation of ICT-based library standards in college libraries of coastal Karnataka.*

A chi-square goodness-of-fit test was conducted to examine the significance of implementation of ICT-based library standards in college libraries of coastal Karnataka. The results indicated a significant difference from the expected distribution, χ^2 (1) f = 102.918, $p < .001$. This suggests that the implementation of ICT-based library standards is significantly present in the college libraries surveyed.

Hypothesis 3: *There is no significant difference in the implementation of ICT-based library standards between government and private college libraries of coastal Karnataka.*

Pearson chi-square test revealed a significant difference in the implementation of ICT-based library standards between government and private college libraries in coastal Karnataka, χ^2 (1) = [6.445], $p = .011$. Thus, the null hypothesis rejected.

Hypothesis 4: *The implementation of ICT-based standards in college libraries of Coastal Karnataka has significantly improved operational efficiency.*

A Linear-by-Linear Association chi-square test was conducted to examine the relationship between the implementation of ICT-based library standards and operational efficiency in college libraries of Coastal Karnataka. The association was found to be statistically significant, χ^2 (1) f= 9.055, $p = .003$, indicating that improved ICT implementation is associated with higher operational efficiency. The p-value (.003) is less than 0.05, so the result is statistically significant.

12. Recommendation of the study

Libraries should upgrade ICT infrastructure, implement standardized automation software with regular updates, and strengthen inter-library networking for better

resource sharing. Regular ICT training is essential for professionals. Adopting and aligning with established ICT standards will enhance service quality, interoperability, and sustainability.

- Encourage professional advancement and leadership opportunities across all library roles.
- Foster mentorship to bridge experience gaps and support career development.
- Encourage the pursuit of advanced qualifications to foster academic excellence and professional growth.
- Strengthen university collaboration to ensure uniform ICT standards and resource sharing.
- Implement consistent ICT policies to ensure equity across diverse college types.
- Promote strategic planning to establish institutions aligned with current educational needs.
- Encourage of institutions to strengthen ICT access in underserved areas.
- Assist unaccredited institutions in obtaining NAAC accreditation to enhance education quality.
- Conduct regular internal quality audits to ensure continual improvement.
- Encourage ICT adoption through support, funding training, collaboration, and strategic digital transformation efforts.
- Provide ICT training for assistants, and support early-career staff with development programs.
- Promote comprehensive ICT adoption through strategic policies, improved infrastructure, and regular staff capacity-building initiatives.
- Bridge ICT disparities by directing resources to institutions with lower NAAC grades and limited facilities.
- Enhance ICT usage through user training, awareness initiatives, and improved access infrastructure.
- Enhance ICT utilization via capacity building, infrastructure development, and institutional support frameworks.
- Foster positive ICT perception in government colleges through awareness programs and institutional support initiatives.
- Facilitate comprehensive ICT integration through professional development initiatives.

- Bolster ICT capabilities in government institutions through comprehensive development programs and policy-driven initiatives.
- Prioritize systematic enhancement and maintenance of ICT infrastructure to ensure reliable and efficient library services.
- Enhance ICT infrastructure and ensure continuous maintenance to sustain effective digital resource accessibility and user satisfaction.
- ICT features through continuous updates, user training, and improved integration with academic platforms.
- Encourage collaborative partnerships and knowledge sharing to accelerate technology integration in under-resourced institutions.
- Implement regular ICT updates through institutional policies ensuring timely and systematic technology renewal.
- Address budget and skill gaps through targeted funding and comprehensive technical training programs.
- Optimize ICT implementation by securing adequate resources, enhancing staff competencies, and reinforcing organizational commitment.
- Accelerate full automation by enhancing infrastructure, training, and strategic planning across all colleges.
- Promote standardized, open-source software like Koha for cost-effective, scalable library automation solutions.
- Formulate national-level guidelines to encourage consistent use of effective library automation systems across institutions.
- Advance library modernization by introducing cloud platforms, kiosks, mobile services, and digital management systems.
- Strengthen underutilized modules like OPAC and Analytics through training, software upgrades, and regular performance evaluations.
- Encourage institutional support for improve implementation of digital library software.
- Consistent digital infrastructure across all college types.
- Enhance in-depth knowledge and effective usage of all digital library software, especially Omeka and Greenstone.
- Promote wider adoption by offering technical support, and awareness on content management software benefits.
- Increase advanced knowledge of Drupal and Joomla.

- Offer continuous training for sustainable and effective technology integration.
- Regular workshops to enhance proficiency in reference management tools and their applications.
- Encourage peer collaboration, self-directed learning, and optimal use of existing digital tools and staff expertise.
- Support effective utilization of available retrieval tools through peer-sharing and practical application in daily operations.
- Encourage consistent monitoring, evaluation, and documentation to sustain and enhance ICT standards implementation effectiveness.
- Promote uniform adoption of library standards through structured policies, institutional collaboration, and regular performance assessments.
- Ensure sustainability by documenting processes, upgrading systems regularly, and aligning with evolving ICT standards.
- Promote resource-sharing, peer learning, and integrating standards into regular library practices.
- Consistent use of IPR standards by integrating them into daily library practices and documentation workflows.
- Incorporate IPR standards into cataloguing routines to reinforce understanding and promote consistent practical usage.
- Integration in workflows, and use in digital resource management.
- Enhance familiarity with web standards through hands-on training, practical integration.
- Promote deeper understanding of networking standards through applied practice, and regular technical updates.
- The benchmarking practices to strengthen adherence to ICT-based library standards.
- Strengthen infrastructure and recruit skilled professionals to improve adherence to ICT-based library standards.
- Ensure consistent support mechanisms to help all libraries meet and sustain ICT-based standards effectively.
- Enhance ICT support services through periodic upgrades, user feedback, and responsive technical assistance for sustained satisfaction.
- Simplify and clarify implementation protocols through regular training, visual aids, and standard operating procedures.

- Assign ICT-skilled professionals to lead innovation-focused teams within the library environment.
- Create performance-based incentives for applying ICT skills in resource management and library development.
- Use free online courses to learn ICT standards and tools
- Motivate staff for self-learning through free platforms and forums.
- Digitize essential resources using available devices and freeware.
- Share best practices through inter-departmental library staff meetings.
- Digitize materials using existing infrastructure creatively
- Focus on sustainable, low-cost digital strategies
- Display infographics on ICT standards in the library.

13. Conclusion

The study on the implementation of ICT-based library standards in Coastal Karnataka's college libraries reveals significant progress overshadowed by systemic inconsistencies. While ICT has modernized operations—introducing automation, digital repositories, and networked services—implementation varies widely. Technological disparities, outdated infrastructure, limited funding, and insufficient ICT training hinder standardization. Though some institutions adopt global frameworks like MARC, ISO 2709, and Z39.50, many struggle due to a lack of awareness and capacity-building programs, resulting in poor bibliographic control and weakened collaboration. The study identifies a critical skill gap among library staff, emphasizing the need for structured digital literacy and professional training. Financial limitations further constrain ICT growth, despite occasional external support. To bridge these gaps, the study advocates for sustained investments, strategic policymaking, and collaborative initiatives. When fully realized, ICT-based standards can enhance interoperability, access, and academic excellence. Achieving this vision requires unified efforts to transform libraries into dynamic hubs of digital learning and scholarship.

14. Future research directions and opportunities

The implementation of ICT-based library standards in college libraries of Coastal Karnataka offers significant scope for further research. As digital transformation accelerates, a deeper examination of technological advancements,

challenges, and best practices is essential to enhance library operations. Future studies can explore the following areas with research title:

- **Standardization of emerging technologies** - Standardizing emerging technologies ensures consistent integration, improves service delivery, supports global alignment, and addresses challenges like interoperability, compatibility, security, and sustainable technological advancement in libraries.
  "Standardization of Emerging Technologies in Academic Libraries: A Study Based on Technology Acceptance and Innovation Diffusion Models"
- **Comparative analysis of ICT adoption** – Assessing the level of ICT implementation across various college libraries to identify gaps and effective strategies.
  "A Comparative Study of ICT Adoption in College Libraries Challenges and Best Practices"
- **AI and automation in library management** – Exploring the potential of artificial intelligence and automated systems in improving library services.
  "Artificial Intelligence in Academic Libraries: A Pathway to Automation and Smart Services"
- **Inter-library networking and collaboration** – Analyzing digital resource-sharing initiatives and their impact on accessibility and efficiency.
  "Enhancing Resource Sharing through Digital Networking in Academic Libraries"
- **Policy framework for ICT implementation** – Developing strategic policy recommendations to strengthen ICT adoption in academic libraries.
  "Strategic Policy Frameworks for ICT Adoption in College Libraries A Roadmap for Development"
- **Smart libraries and IoT integration** – Investigating how smart technologies and the Internet of Things (IoT) can revolutionize library management and user engagement.
  "Building Smart Libraries the Impact of IoT on Library Services and User Engagement"

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